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VOL. IV. NEW YORK, DECEMBER, 1899. No. 10

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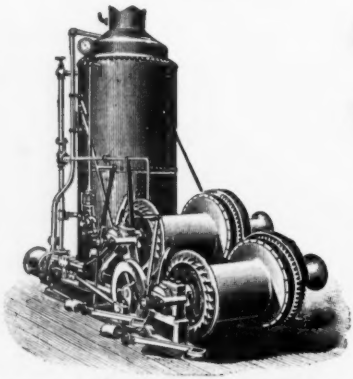

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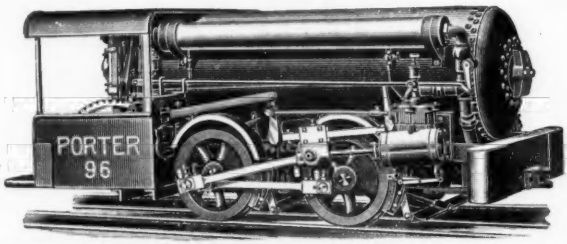

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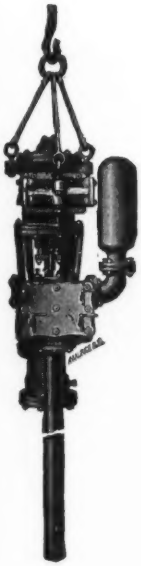

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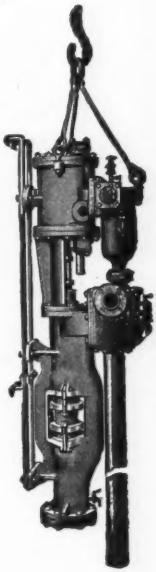

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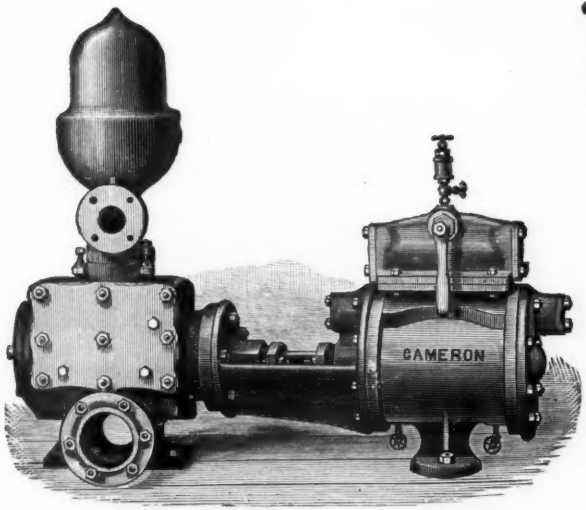

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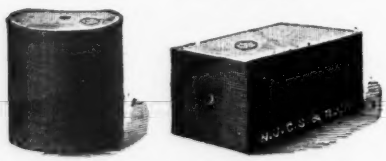

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VOL. IV. DECEMBER, 1899. NO. 10.

The several papers which have been published serially in this paper, written by Mr. Victor Popp, of Paris, are worthy of serious study by those interested in the practical application of compressed air. Mr. Popp writes from a practical, as well as a theoretical standpoint. His large experience and the success of his work entitle him to the position which he holds as a recognized authority on this subject, and we doubt that there has been published anywhere so important a series of papers giving such practical information as those written by Mr. Popp. We have been accustomed to read highly technical matter on this subject, and engineers are prone to deal in formulas and calculations, which are interesting enough to theorists, but which really bring no practical results. Mr. Popp, without neglecting theory, treats of the subject in so practical a manner that his theoretical deductions are easily understood, and they add to the value and reliability of the practical information which he gives.

Professor Riedler has said that Mr. Popp was the first to successfully use the reheating system with good results. We think it quite true that the first practical reheater was used in Mr. Popp's system, in Paris. A great many desultory experiments were made, and reheaters of many kinds were put in use in America; but Mr. Popp's heater was the first one to give practical results, and to be applied in continuous service. Mr. Popp is also the author of a very interesting system of Pneumatic Traction, which has recently been introduced into France. Two trams of the Popp system are running at Vincennes, in competition with the Mekarski cars. It is generally known that the Mekarski cars have been running in France for more than ten years, and that they have been giving good practical results. The Popp cars appear to be superior to the Mekarski in many ways, they are lighter in weight, more simple in construction, and under easier control by the motorman. Besides these advantages, the Popp car is reversible, it being simply necessary to transfer the brake-wheel and certain light parts from one end of the car to the other, and start the car in the opposite direction. An important point of difference is in the system of reheating. The Mekarski car using the "wet" system of reheating, while Mr. Popp applies the "dry" system. In the wet system it is well known that water heated by the introduction of steam, is used for warming the air, and that the air passing through this hot water, carries with it a certain amount of moisture. Apart from the expense involved in producing heat through steam, the wet system has other disadvantages, viz.: the tanks occupy space, time is required to heat the water at the end of the line, and in a long run the temperature is considerably lowered. Another disadvantage, and one which is seldom touched upon, is that wet air, like wet steam, helps

to destroy the cylinders, pistons, and other moving parts. Though the air is hot when it enters the cylinder, it is soon cooled below the dew point by expansion, and deposits its moisture; so that what at first appears to be an advantage in vapor from water mixed with air, is only an advantage while the air is hot, and is a distinct disadvantage when condensed and left in the cylinder. Water in cylinders wipes away the oil, and is a source of destruction howsoever clean the water may be. It is a mistake to suppose that water is a lubricant; on the contrary, it interferes with lubrication. Mr. Popp overcomes these difficulties by the introduction of a small dry heater, burning coal, charcoal, or coke, the draught for which is made by the exhaust from his motor. It is always easy to get coal and coke, and the quantity used in a tramway heater is so small that it does not materially affect the cost of operation; besides, it is difficult to over-estimate the value of reheating.

On this subject, we would refer our readers to recent numbers of this little magazine, more especially to the October number, in which a description is given of Mr. Popp's heater, together with figures and data based on experience. Mr. Popp gives us the figures to show that, according to Professor Guttermuth's experiments, one kilogram of combustible will, under good circumstances, give up as much as much as 5,600 calories in an air heater. This result Mr. Popp goes on to say "being superior by at least 500 per cent. to the results obtained by the best triple expansion compound condensing engine," and again it is interesting to note the statement made by Mr. Popp that "the amount of coal required for reheating air for large motors being 0.2 of the pound per h.-p. hour." This, as engineers will see, is about six times more efficient that the best results obtained in producing compressed air through our best corliss engine system.

In an article which follows that of Mr. Popp, in the October number, some interesting figures on this subject are given by Professor Nicolson, in a report on trials made at Magog,Quebec, to test the economy effected by preheating compressed air. This article is also worthy of very serious consideration and study. It impresses us as practical, and as of value as a matter of reference. The system which Professor Nicolson refers to, is the well-known Taylor system of compressing air by the flow of water. This had been in successful operation at Magog, and as a water power installation on a large scale, it is a success of the highest scientific interest. Professor Nicolson gives us some figures showing comparisons between the wet and the dry systems of reheating, concluding by saying that wet heating is inferior to dry heating. He quotes Professors Riedler and Guttermuth as having obtained an additional power in air motors for every three-quarters pound of coal burnt to heat the air, and goes on to say that this is an economy "far surpassing that of any prime motor in existence." We think this latter statement will not be questioned by engineers, nor does anyone doubt the correctness of the results obtained by Professors Reidler and Guttermuth; these results as remarkable as they are, are capable of considerable improvement when a perfect reheater has been designed. Thus far, our best reheaters in practical service do not convert the maximum amount of fuel into expansiveness of the air, while it is quite within reason to expect almost a complete conversion of the theoretical efficiency of a pound of coal into expanded air by a thorough system by which all the heat produced by burning the coal is transferred into the air. Then again, we have

further possibilities in reheating air because the science is likely to develop into compound engines using air at different pressures, and reheating between each stage.

So economical in results is the system of using reheated air, that it is quite possible to restore at very little expense in fuel all, or nearly all, the power expended at the generating station, and lost through the heat of compression, friction, leakages and other conditions that will always exist in a compressed air installation. The encouraging point about the use of compressed air, is that notwithstanding these losses, there still remains boxed-up a cold elastic substance, which is capable of taking up heat in large quantities and expanding in proportion as the heat is applied. In no other power are there such opportunities, because we must all admit that in every other known form of power it is impossible to restore energy lost at the generating station or along the line, except at an expense that makes it prohibitive. It is often said that compressed air is only a means by which power is transmitted, and is not a power in itself. We now see that through reheating, compressed air is justly entitled to be called a source of power; and not merely a means of transmission.

Liquid Air

Latent Heat of Evaporation of Liquid Air.

By Walter H. Dickerson, M. E., '96.

During May, 1898, the writer, in connection with Professor D. S. Jacobus,* made some determinations of the latent heat of evaporation of liquid air at the Stevens Institute of Technology.

As a result of the investigation the latent heat of evaporation at atmospheric pressure was found to be 123.0 British thermal units per pound.

The method of determination was as follows:

A large mercury mirror Dewar vacuum bulb was employed to contain the liquid air. The vacuum bulb consisted simply of two glass bulbs, one within the other, and joined in a short neck.

These bulbs have, between the walls, an annular space of about one-half inch, which is exhausted to a very high vacuum. If a drop of metallic mercury is originally introduced into this vacuum space, it will be changed into vapor when the vacuum is formed. On filling the inner bulb with liquid air, the mercury vapor in the vacuum space will be condensed on the surface of the inner bulb and a mercury mirror formed. The vacuum space prevents ingress of heat to the liquid air by direct convection and the mercury mirror intercepts the radiant heat so that the rate of evaporation in this form of containing vessel is very low.

The vacuum bulb was filled with liquid air and weighed, and the rate of constant evaporation due to the heat of the atmosphere determined. A small bar of metal of known weight and temperature was then introduced into the liquid air and after it had acquired the temperature of the liquid, it was withdrawn and the bulb weighed again, the length of time the metal bar was in the liquid air being noted. Then, knowing the initial and final temperatures, specific heat, and weight of metal bar, and also the weight of the liquid air evaporated, the latent heat of evaporation of the liquid air could be calculated.

No means were at hand to determine the temperature of the liquid air and it was therefore taken as the boiling point at atmospheric pressure and temperature, given by Prof. Dewar and others as —312° F., or —181.4° C. Although the liquid air used was slightly richer in oxygen than the ordinary atmospheric air, the error due to the difference of temperature from this cause was considered well within the error of other observations and was therefore disregarded.

There were three determinations made, with a different metal in each instance. The three metals used were iron, copper and aluminum, each in the form of a

**It is very generous of Mr Dickerson to mention my name as I did not assist him except in placing apparatus at his disposal.—D. S J.*

small cylindrical bar. The specific heats of these particular bars had previously been determined for a range of temperature from the atmosphere to the boiling point of liquid air with the following results:

Metal.	Weight of Bar in grammes.	Specific Heats.
Iron	51.925	.0914 for range of temperature of from + 13.°C. to—181.4°C.;
		.1162 for above + 13.°C.
Copper	63.49	.0868 from + 11°C. to—181.4°C.
		.094 for above + 11.°C.
Aluminum	19.865	.1833 from + 14.5°C. to—181.4°C.
		.2173 for above + 14.5°C.

During the tests the following observations were noted:

First Experiment with Iron Bar.

Temperature of atmosphere, 23.9°C.

Temperature of iron bar, 23.6°C.

Total weight of vacuum bulb and liquid air before immersing iron bar, 338 grammes.

Total weight after iron bar had acquired temperature of liquid air and been withdrawn, 319 grammes.

Time between weighings, 10.5 seconds.

Rate of constant evaporation per minute due to heat of atmosphere, .4286 grammes.

Total constant evaporation, 4.500 grammes.

Net evaporation due to iron bar, 14.5 grammes.

Heat units in iron per gramme,

+13° C. to —181.4° C. = 17.768
+23.6° C. to +13° C. = 1.232

Total heat units per gramme.. 19.000

Total heat units in iron bar in grammes-calories, +23.6° to —181.4° = 986.57.

Latent heat, by iron bar, 68.03 calories.

Second Experiment with Copper Bar.

Temperature of copper bar, before immersing, 23.2° C.

Weight of bar, 63.49 grammes.

Weight of vacuum bulb and liquid air before immersing copper bar, 312 grammes.

Weight of vacuum bulb after bar had acquired temperature of liquid air and been withdrawn, 291 grammes.

Time between weighings, 10.92 minutes.

Rate of constant evaporation per minute due to heat of atmosphere, .4342 grammes.

Total constant evaporation, 4.741 grammes.

Total evaporation, 21 grammes.

Net evaporation due to copper bar, (21 —4.741) 16.26 grammes.

Heat units in one gramme copper,

+ 11° C. to —181.4° C. = 16.70
+ 23.2° C. to + 11° C. = 1.15

Total, + 23.2° C. to —181.4° C. 17.85

Total heat of copper bar in gramme-calories 1126.948.

Latent heat of evaporation of liquid air by means of copper bar, 69.31 calories.

Third Experiment with Aluminum Bar.

Temperature of aluminum bar before immersing, 23° C.

Weight of bar, 19.865 grammes.

Weight of vacuum bulb and liquid air before immersing aluminum bar, 284 grammes.

Weight of vacuum bulb after bar had acquired temperature of liquid air and been withdrawn, 269 grammes.

Time between weighings, 9.4165 minutes.

Rate per minute of constant evoparation due to heat of atmosphere, .4166 grammes.

Total constant evaporation, 3.9229 grammes.

Total evaporation 15 grammes.

Net evaporation due to heat of aluminum bar, 11.077 grammes.

Heat units per gramme of aluminum.

+14.5° C. to —181.4° C. = 35.908
+23.° C. to + 14.5° C. = 1.847

Total 37.755

Total heat in aluminum bar used, 750.1 calories.

Latent heat by aluminum bar, 67.72 calories.

Average latent heat by iron, copper and aluminum bars, 68.35 calories.

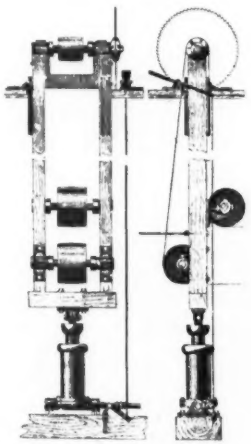
Latent heat expressed in B. T. U. per pound, 123.03.

The writer wishes to express his thanks to Mr. Chas. E. Tripler for so kindly furnishing the liquid air with which to make the investigation; also to Prof. Trowbridge, Columbia University, for loaning the metal bars and furnishing the data of the respective specific heats.—Stevens Institute Indicator.

Compressed Air Machinery

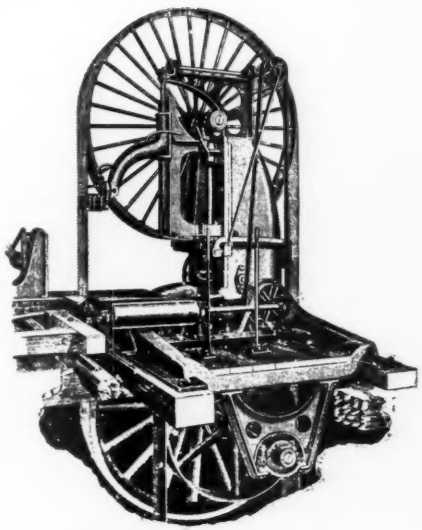
Compressed Air in a Saw-Mill.

In the early part of 1898 a compressed air plant was installed in the sawmill of



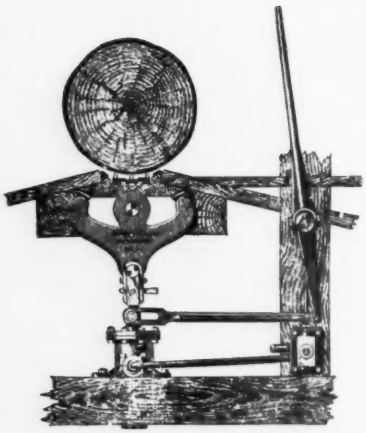
STEAM FEED CUTTING-OFF SAW.

Wm. Engel & Co., Orono, Me., and all the appliances hitherto actuated by steam



THE NEW "ALLIS" BAND MILL.

were made to run by compressed air. The chief object of adopting compressed air to operate sawmill appliances was to minimize the fire risk. Instead of dangerous belts, pipes now conduct the power and the details of the plant will prove interesting. An Ingersoll-Sergeant Class "B" Air Compressor is operated by a large water wheel. Air is compressed and stored in a receiver and distributed through pipes to any part of the mill desired. The power generating plant, consequently, is so simple that any person of ordinary intelligence can easily superintend its operation. The machinery in use at the Wm. Engel mill is the same as that used in steam sawmills. Air at 90 to 100 lbs. pressure is carried in the receiver and pipe line to the different machines that air is used in. The following devices are necessary to operate modern sawmills, and combined with the use of compressed air the method of producing lumber may be fairly realized.



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Allis Jump Saw Rig.

Air is used to raise and lower an Allis Jump Saw Rig that is placed in the log slide to cut off the logs at the right length.

Allis Log Flipper.

This machine throws the log out of the log slide on the log deck, where they are stopped by a

Kline Log Roller.

This appliance holds them in place until the sawyer wants the log on the carriage, when he does the same as he would in any steam mill, that is, step on the treadle in the floor; the air does the rest. At the same time he has one hand on the

Hill Steam Nigger Lever

and the other hand on the carriage lever; when the air gets in its work again with the nigger he places the log just right to saw and with

Beck's Twin Engine Feed

that runs the carriage back and forth to the

Band Saw,

which puts the logs into lumber, which goes on down the mill on live rollers to some Allis Jump Saws that set in the roller casing to trim the lumber and timber work, also to cut up edgings and slabs. Besides the machines which have been spoken of which use the air successfully are a

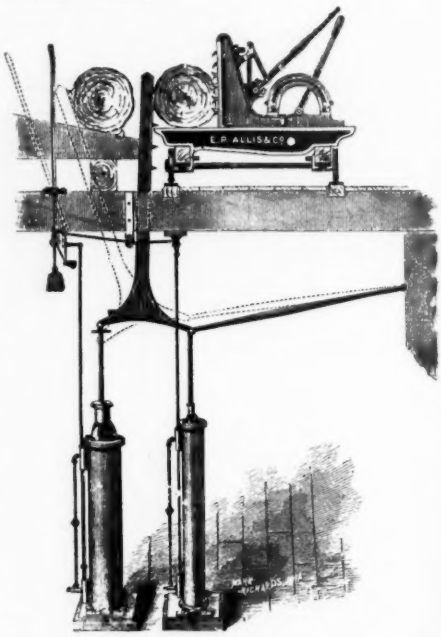
Steam Pump

for fire protection, it is also used to blow a large

Large Whistle

to start and stop the mill at meal times.

This mill is operated 11 hours per day and produced from 50,000 to 65,000 feet of lumber daily, and goes to show that compressed air does the work as well as steam, with the advantages of lowering the rate of insurance, which is extremely high on sawmill plants, and the avoidance of disagreeable conditions that the use of steam entails.



HILL'S PATENT DOUBLE CYLINDER STEAM NIGGER. OPERATED BY COMPRESSED AIR.

Reducing Air from High to Low Pressure.

The use of compressed air, especially in cases where it is stored under a high pressure, has created a demand for a regulating valve that will reduce this high pressure to the normal working pressure desired in engines or elsewhere.

The chief difficulty experienced in effecting a reduction from 1,000 lbs. or more, per square inch, to a working pressure of from 100 to 200 lbs., has been found to lie in the fact that, with the maximum initial pressure in the reservoir, the reducing valve was opened to such a slight extent that the excessive wire-drawing, and the lodgment of fine particles of scale, cuttings, grit or other foreign substances which are always present under ordinary practical conditions, has resulted in so rapid a wearing of the seats and valves that the leakage quickly became serious, and the tight closing of the valve an impossibility. This difficulty has been entirely obviated by the Foster combination regulator and automatic stop valve.

The valve is made in two forms: one operated mechanically, and the other pneumatically. In the mechanically operated valve, (Fig. 1,) the high pressure is admitted through the pipe 16, and when the valve in the body C is open, the full pressure of air flows in to the valves of the regulator in the case A. These valves are controlled by a diaphragm and the springs K, K, as in the standard "Class W" Foster regulator. Here it is reduced or wire-drawn down to the normal working pressure, and flows out through the pipe 17. So long as the throttle remains open, and there is a consumption of air, this state of things continues. When, however, the throttle is closed, the valve in the body C is also closed, and all flow of air from the supply pipe 16 to the regulator valve is cut off—a pipe being tapped in to the body C between the valve and source of supply. This pipe leads to the auxiliary valve B, which may be located in any convenient place in juxta-position to the engine throttle lever, and is always charged with high pressure air from the pipe 16. In B there are two small needle valves, one closing downward and held in that position by the combined pressure of

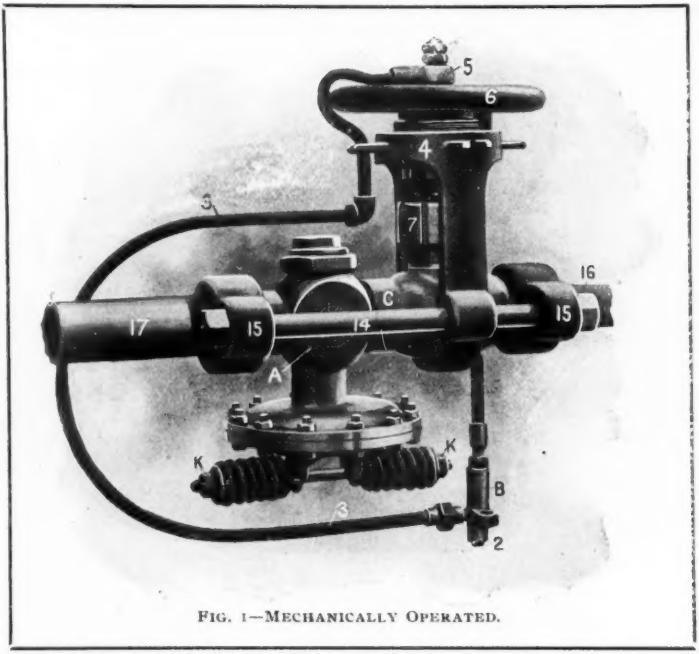


FIG. 1—MECHANICALLY OPERATED.

a spring and the high pressure air. Abutting against this valve, and held open by it, is an upward closing valve which projects below the case at 2. When the engine throttle is closed, an adjustable screw in the lever thereof pushes this valve 2 shut and, in doing so, opens the one above it. The opening of this upper valve allows the high pressure air to pass around through the pipe 3, and thence back to the joint 5, and down the center of the spindle to the top of a piston within the casing 4. This piston rests on the same stem as the valve in the body C, and when air pressure is admitted to the top of the former, the latter is closed, thus shutting off the flow from the pipe 16.

As soon as the throttle is opened, the pressure instantly closes the upper valve in B and, in so doing, opens the valve 2, which allows the air above the piston in 4 to escape to the atmosphere. The valve in C is then opened by the pressure from the pipe 16 beneath it, and air is again admitted to the regulator valve A.

The valve in body C can also be closed by means of the hand-wheel 6, after the manner of an ordinary stop valve.

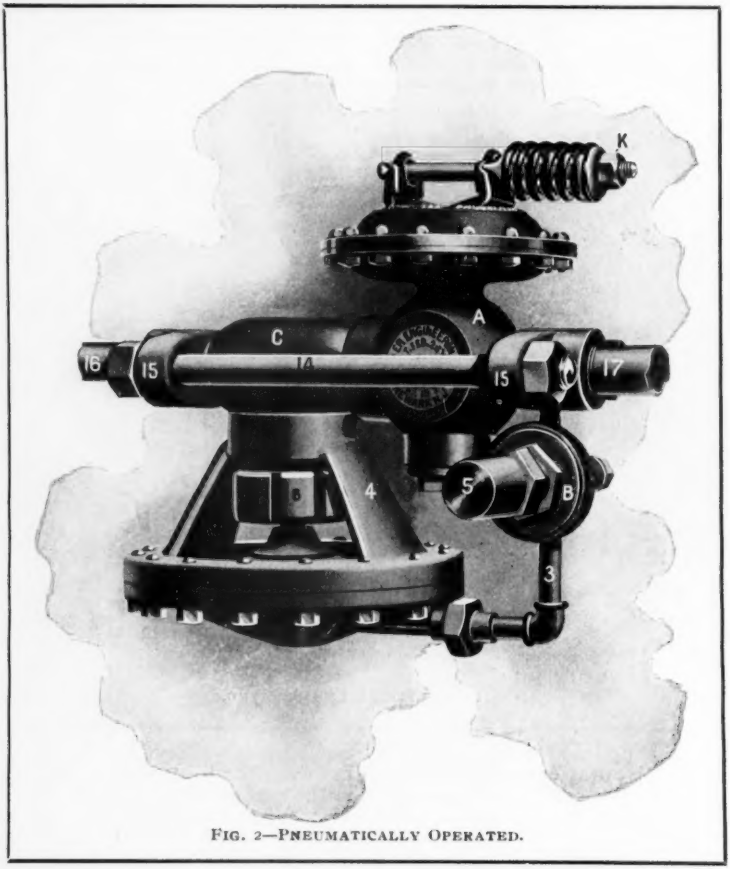


FIG. 2—PNEUMATICALLY OPERATED.

In the case of the pneumatically actuated valve (see Fig. 2) the high pressure air is admitted at 16 and flows through the valve C to the regulator valve A, where the pressure is reduced as desired and whence it flows out at the delivery 17. Tapped into the delivery pipe

17 is a small pipe leading down to the auxiliary valve B, where it enters beneath a diaphragm which is adjusted by a spring in the casing 5, so that the valve will open when the pressure in pipe 17 has risen a small amount above the normal working pressure. When such a rise has taken place, this valve opens and air passes through the pipe 3 to the back of a diaphragm working against a plate on the stem of the stop valve in C. The admission of this pressure to the back of the diaphragm closes the valve C and cuts off the flow of air. As soon as the working pressure again falls to normal, the needle valves in casing B shuts off admission from pipe 17 and bleed the air from back of diaphragm in stop valve C to the atmosphere and allow this valve to instantly open.

The result of this combination is that the valve in C is always either wide open or closed. There is, therefore, no wire-drawing at this point, and the ample opening of the valve permits any foreign substances that may be entrained by the air, to blow through. When the valve C is closed, that in A opens more than it does when in the normal working position, due to the fall of pressure that takes place. Hence, at the instant of the opening of C, a puff of air is sent through A, cleaning the seats and preventing a lodgment of the grit.

The cutting of the valve surfaces due to wire-drawing is obviated by the use of a hardened steel valve, which has been found to be efficient for the purpose.

Theoretical

Heat Required to Raise the Temperature of Air.

Air, in common with all other gaseous substances, possesses the property of requiring various amounts of heat to raise its temperature through a given range, according to the circumstances under which the heat is applied. This point is of so much importance that an entire article would be needed to elucidate it properly; but for the present it will be sufficient to say that the "specific heat" here given for air (*i. e.* the number 0.238) assumes that the air that is to be heated is constantly at atmospheric pressure—that is, it assumes that throughout the entire process of heating, the air is never exposed to a pressure that is sensibly higher or lower than that of the atmosphere. This condition is often fulfilled in practice, and the specific heat here given will therefore be found useful. When other conditions prevail, however, some different value must be used for the specific heat—a value that can be determined only when the new conditions are fully given.

In calculating the number of heat units required to warm a given mass of air from one temperature to another one, we proceed

WEIGHT OF A CUBIC FOOT OF AIR, AT ATMOSPHERIC PRESSURE (.0 to 600° F.).

Temperature of Air. (Fahr.)	Weight of a Cubic Foot. (Pounds.)	Temperature of Air. (Fahr.)	Weight of a Cubic Foot. (Pounds.)	Temperature of Air. (Fahr.)	Weight of a Cubic Foot. (Pounds.)	Temperature of Air. (Fahr.)	Weight of a Cubic Foot. (Pounds.)
0°	.0864	100°	.0710	200°	.0603	300°	.0523
10	.0846	110	.0698	210	.0594	320	.0510
20	.0828	120	.0686	220	.0585	340	.0497
30	.0811	130	.0674	230	.0576	360	.0485
40	.0795	140	.0663	240	.0568	380	.0474
50	.0780	150	.0652	250	.0560	400	.0463
60	.0765	160	.0641	260	.0552	450	.0437
70	.0750	170	.0631	270	.0545	500	.0414
80	.0736	180	.0621	280	.0538	550	.0394
90	.0723	190	.0612	290	.0531	600	.0376

precisely as we did in the case of iron; that is, we first calculate the heat that would be absorbed by an equal weight of water, and then we multiply by 0.238, which is the "specific heat" of air (at constant pressure.) Air is usually estimated in cubic feet instead of in pounds, because it is much easier to measure its volume than its weight. If, therefore, we have a certain volume of air given, and we wish to find out how much heat will be required to warm it through a certain range of temperature, we must first find out how much it weighs. To accomplish this without too much labor we may make use of the accompanying table, which gives the weight (in pounds) of a cubic foot of air at various temperatures, but always at atmospheric pressure.

To illustrate the use of this table, and the method of calculating the number of heat units required to heat a given mass of air through a given range of temperature, let us take the following problem: It is proposed to heat a mass of air from 50° Fahr. to 110° Fahr., by passing it, at atmospheric pressure, over a coil of steam pipe. The proposed mass of air, when measured at 50° Fahr., occupies 500,000 cubic feet. How many heat units will be required? To solve this problem we first find out how much the air *weighs*. By referring to the table we see that one cubic foot of air, at 50° Fahr. and atmospheric pressure, weighs 0.078 of a pound. Hence 500,000 cubic feet (measured under these same conditions) will weigh

$$500{,}000 \times 0.078 = 39{,}000 \text{ pounds.}$$

Having found the weight of the air in this manner, we proceed to calculate the amount of heat required by first figuring it as though the substance to be heated were water. Thus the initial temperature is 50° and the final temperature is 110°, and the difference between these is 110°—50°=60°, which is the number of degrees through which the temperature of the mass must be raised. There being 39,000 pounds of the air, we should have to communicate

$$39{,}000 \times 60 = 2{,}340{,}000 \text{ heat units}$$

to it, if it were *water*, in order to heat it from 50° to 110°. To take account of the fact that the substance is *air* instead of water, we multiply this result by 0.238 (the "specific heat" of air at constant pressure), just as in the case of iron we multiplied by 0.117. Thus we have

$$2{,}340{,}000 \times 0.238 = 556{,}920 \text{ heat units,}$$

which is the quantity of heat that would be required to raise 500,000 cubic feet of air from 50° to 110°, the air being measured at 50° Fahr., and its pressure remaining equal to that of the surrounding atmosphere throughout the operation.

Curves showing Temperature of Air during compression.

Two curves are shown in the diagram, the ordinates representing pressures and the abscissae volumes. The curve drawn in full line shows the compression of air without any cooling effect, while the one drawn in dotted line shows the compression of air at a constant temperature. The former is the adiabatic curve whose equation is

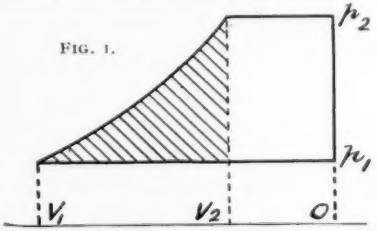
$$\frac{p_2}{p_1} = \left(\frac{v_1}{v_2}\right)^{1.408}$$

the latter is the isothermal curve and has the equation

$$p \times v = \text{constant.}$$

In single stage compression the power required for compression may be calculated

FIG. 1.

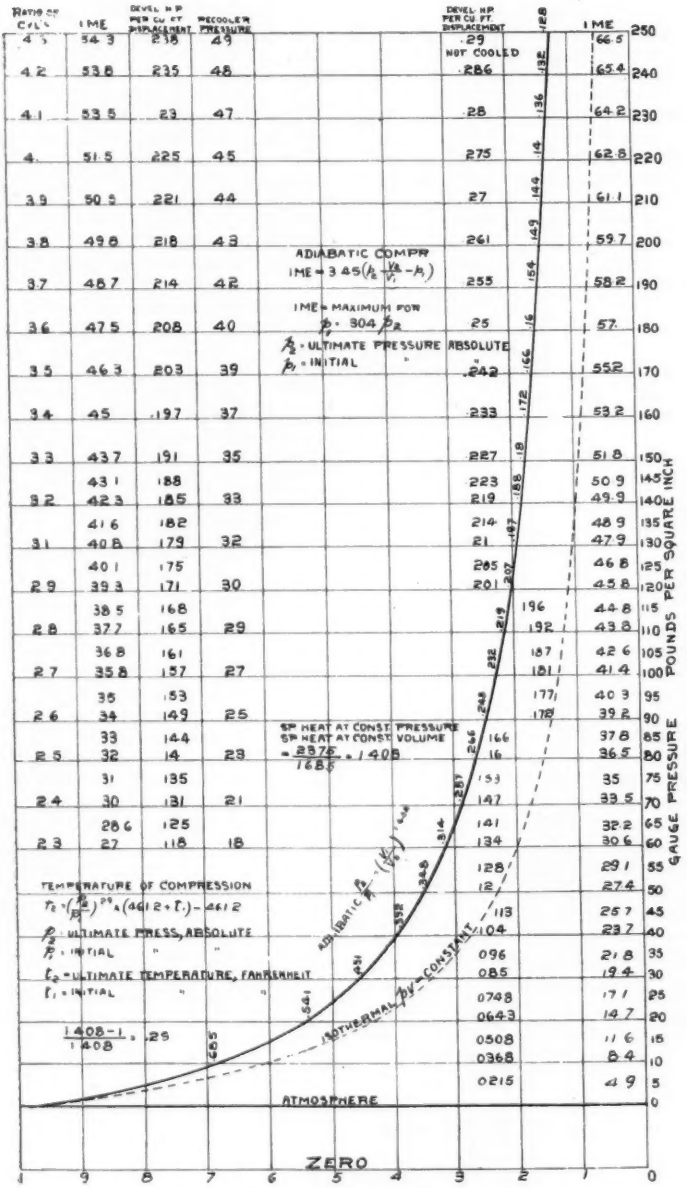


without taking into consideration the slight cooling effect due to the water jacket; the air will, therefore, be assumed to follow the adiabatic curve.

Starting at the left the first column of figures gives the gauge pressure for each horizontal line. The second column gives the Indicated Mean Effective Pressures. These were calculated by a formula which was derived in the manner shown in figures 1 and 2.

The area of the shaded portion of the diagram fig. 1 is

$$= \frac{p_2 v_2 - p_1 v_1}{1.408 - 1} = 2.45\,(p_2 v_2 - p_1 v_1)$$



AIR DIAGRAM BY F. F. NICKEL, BOND HILL, O.

In order to get the area of the shaded portion of the diagram fig. 2, which represents the work done during the stroke of the air piston we have to add

$$p_2v_2 - p_1v_1$$

this makes the

$$\text{Area} = 3.45\,(p_2v_2 - p_1v_1)$$

Dividing this by v_1 will give us the

$$\text{I. M. E.} = 3\,45\left(p_2\frac{v_2}{v_1} - p_1\right) \text{ formula (1)}$$

The third column gives the Horse Power required to compress one cubic foot of free air, measured by the displacement of the air piston.

When p = I. M. E. pressure in lbs. per sq. in.
a = area of air piston in sq. in.
P = piston speed in feet per min.
D = displacement in cubic feet per min.

then

$$H.P. = \frac{a \times p \times P}{33000}$$

$$D = \frac{a \times P}{144}$$

and the Horse Power required per cu. ft.

$$\frac{H.P.}{D} = \frac{a \times p \times P}{33000} \times \frac{144}{a \times P}$$

or

$$\text{H. P. per cu. ft.} = .00437P \text{ formula (2)}$$

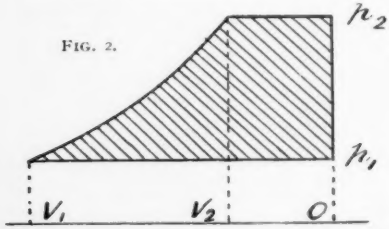


FIG. 2.

The four columns at the left give similar data for two-stage compression. The I. M. E. pressures were calculated for air partly cooled by taking a mean between the pressures obtained by adiabatic and isothermal compressions.

The ratios of cylinders given will distribute the load evenly among the two cylinders; they may, of course, for practical reasons, be varied considerably without impairing the efficiency of the machine.

Formula (1) for the I. M. E. pressure will, for the two extreme cases

$$p_1 = o \text{ and } p_1 = p_2,$$

give the value I. M. E. $= o$.

It is evident that between these two values there must be a maximum. This will be obtained when

$$p_1 = .304\,p_2 \text{ formula (3)}$$

This formula will be found useful in calculating gas compressors where the gas comes in under a head but is expected to drop to atmospheric pressure in the future. The driving mechanism of such a compressor should be calculated for this maximum.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz., all communications should be written on one side of the paper only; they should be short and to the point.

West New Brighton, S. I.
October 29, 1899.

Editor "Compressed Air":

Will you kindly publish in "Compressed Air," a feasible method of testing a pipe line for leakage?

The line in question supplies a dozen or so of Pedrick & Ayer Hoists and it comprises a two stage compressor 12 in. x 8 in. x 12 in. stroke, has no reservoir, but compresses directly into the pipe line.

C. Lee Straub.

There are a number of factors which should be given before an accurate answer can be made. Using the data mentioned, it seems that the most satisfactory method would be about as follows:

If the pipe line has valves at all branches, and a valve between the compressor and the beginning of the pipe line, the branch valves should all be closed and the compressor run until the air pressure in the transmission line is at the maximum for which the machinery was designed. The valve between the compressor and the pipe line should then be closed, and the full pressure in the pipe line noted.

If there are no leaks it would be seen that the pressure would hold up for a considerable time, and the time required for the pressure to drop from maximum to, we will say half pressure, will be a measure of the amount of leakage.

Another way, although not as satisfactory, would be to shut the system down, or make the test when it can be shut down without inconvenience, and pump the transmission line full of water up to the maximum pressure. Leaks would then be indicated by wet spots. If there are no valves at the branches and the air is allowed to pass through flexible connections to the hoist, and is shut off by the hoist valves, this method would not be advisable. The air method, however, could be used in exactly the same way, or the flexible air pipes could be disconnected and cups screwed on the branches.

Another method in very common use is to place oil around the seam or joint in question and in case of a leak the air will blow bubbles of oil. Application is easily made by means of the ordinary "squirt oil can" used around machine shops.

The soapsuds method is perhaps the simplest. Take a strong solution of soap and water and with a clean paint brush apply the suds to the pipe, beginning at the compressor and following to the last appliance. Wherever there is a leak bubbles will appear. Mark these places with chalk for future attention.

Pneumatic Tools

The Chicago Pneumatic Tool Company, manufacturer of the Boyer pneumatic tools, scored an important victory last week in its patent litigation with the American Pneumatic Tool Company of New York. Between three and four years ago the American Company brought suit at New Haven, Connecticut, against a concern which was using one of the Boyer tools, and succeeded in obtaining a preliminary injunction on the strength of an old decision it had obtained sustaining its patent. Upon obtaining this preliminary injunction, the American Company sent every concern using Boyer tools a notice of infringement, in which it claimed some two millions of dollars damages against the users of Boyer tools. The Boyer people promptly took an appeal from the preliminary injunction order, and the order was reversed by the Court of Appeals at New York City. This was about three years ago, since which time the suit has been progressing toward a final hearing on its merits. It was argued at great length before Judge Townsend, in the United States Court at New Haven, last June, and has been held under advisement by the court until last week, when Judge Townsend handed down an exhaustive opinion, holding with the Boyer people on every point and declaring that the Boyer tools did not infringe the American Company's patent. The court also took occasion, in its opinion, to condemn the conduct of the complainant company in sending out the circulars above referred to for the purpose of scaring and intimidating purchasers of the Boyer tools.

We have received the following notice relative to patent litigation:

Chicago, Ill., Nov. 29, 1899.

We wish to notify all our customers and the trade in general, that in the patent litigation entered into between the Chicago Pneumatic Tool Company, Joseph Boyer, the Standard Pneumatic Tool Company and the Chouteau Manufacturing Company, all suits have been dismissed by the advice of their respective attorneys, they recognizing that the Boyer and Chouteau Patents cover the fundamental principles of all Pneumatic Hammers, without the combined use of which no successful Pneumatic Hammer can be made.

Recognizing the value of their respective claims, they have purchased licenses from each other covering their present style of hammers.

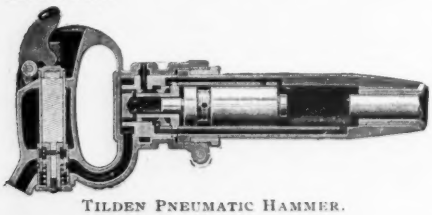
We consider this action necessary for the protection of users of our respective tools.

Chicago Pneumatic Tool Co.,
By J. W. Duntley, Pres.
Standard Pneumatic Tool Co.,
By Edward N. Hurley, Pres.

The cut herewith shows that type of pneumatic engines in which the reciprocating piston constitutes a hammer, adapted to deliver a series of rapidly recurring blows to a chipping, caulking, beading, riveting or other tools, the

shank of which is located in the path of such impact piston, and constitutes an end closure for the lower piston chamber.

The objects of the present improvements are: First, to provide a simple and efficient sectional formation and arrangement of the main cylinder for the impact piston, and the valve block and housing for the reversing valve, which permits of a ready and convenient detachment of the parts for cleaning, etc. Also to provide means for connecting the handle, main cylinder and valve block and housing together in a rigid and substantial manner. To provide means, self-contained within the hammer, for automatic lubrication of the hammer parts while in operation. To overcome recoil and dispense with the vibration or jar (so objectionable in most hammers) which enables the operator to accomplish greater results with less fatigue. In this hammer there are but two moving parts, the piston and valve, which, by the arrangement of the air passages, control each other.



TILDEN PNEUMATIC HAMMER.

The sectional view herewith gives an idea of its construction and operation. Starting with the parts in the position as illustrated, the motive fluid or compressed air from the main chamber passes through ports into the valve block chamber to press upon the upper end extension of the impact piston, and acting against the decreased area thereof imparts a light initial movement to the piston, which from practical experience is found to be very efficient in reducing the amount of jar or vibration.

Letters patent were issued Oct. 24, 1899, to Robert Burns and B. E. Tilden, and the manufacture of same will be immediately commenced by the International Pneumatic Tool Co., of 1209 Monadnock Block, Chicago, Ill., under the management of B. E. Tilden and C. J. Fellows. To designate this from other hammers it is called "The Tilden."

The cut on cover shows the New Boyer Long Stroke Riveting Hammer on car work at the Pressed Steel Car Company's shops in Allegheny, Pa. These Long Stroke Hammers are the most powerful pneumatic hammers ever made, and are meeting with the highest success in all classes of riveting. Ten of them were put in the Pressed Steel Car Company's shops, and after using them and subjecting them to tests on all kinds of work, they have ordered 60 more, making 70 to be used at that plant.

They are also very successfully used on boiler work having capacity of drilling rivets up to 1¼ in. in diameter in the best possible manner.

At the shops of John Mohr & Sons in Chicago, they reported that an inexperienced man with one of these hammers accomplished the same amount of riveting in 30 hours for which their experienced riveters had previously required 80 hours, and that all was first class and steam tight when tested under pressure.

They are so well adapted to all classes of work that orders are coming in practically unsolicited, about 200 of them having been sold last month. They mark the greatest advance yet made in pneumatic hammers and will interest all having a large amount of riveting to do.

Air Jets

Farraday in 1823 liquefied all except six of the existing gases.

He accomplished liquefaction in 1869; Pictet in 1887; Caillete in 1887; Dewar, in 1893; Linde, Hampson, and Tripler in 1897; Ostergren in 1899.

The Eclipse pneumatic tools sold by W. J. Schaefer & Co., 33 Barclay street, New York, are well described in a catalogue received. Smaller tools for chipping and caulking are illustrated and fully described, and much information is given regarding them. Larger tools, such as rotary drills, etc., are also shown.

Several war ships and other vessels have been provided with a system for closing bulkhead doors in case of a leak or accident. The most approved system is one that uses compressed air. The "Long Arm" system is used on the U. S. protected cruiser Chicago and by its application in an instant the doors of the bulkhead can be closed. A central station for compressing the air may be placed in any convenient location and usually consists of a small three stage air compressor, operated by steam or electric motor, with an air receiver consisting of the required number of storage flasks for the desired emergency capacity. Air is kept in the receiver at about 1,000 lbs. pressure and it is used at 150 lbs. pressure, and there is always enough power stored to operate all of the doors without having to wait until the air is compressed. The pipe line runs to all points where the closing mechanism is located, and is controlled from an emergency station automatically. The door slides vertically between two guides. A cylinder is attached to the door and a piston moves it up or down. In case of need the pipe line is opened and the pressure exerted on the piston head forces the door down and closes it. Some interesting experiments have been tried with this system. In one instance a pile of wet coal lying 30 in. deep above the sill obstructed the closing door, but the water swept it away and the door closed against the water pressure. In another case the door closed down upon the coal and was locked in that position. From the progress being made by the "Long Arm" System Co., of Cleveland, Ohio, it is likely that they will succeed in extending their system to every branch of marine service.

The University of Illinois announces, among others, the following subjects for senior theses now in course of preparation:

"Experiments with compressed air, including a study of the history and development of its uses, with tests of power required, flow of air through pipes and valves, and experiments to determine consumption of air when used as power for hoists and drills.

"The use of compressed air for pumping water, with description and test of a plant in operation and tests of various lifts and pumps."

The Russian Government has issued an order to the Westinghouse Air Brake Co. involving the equipment of 300,000 freight cars, as well as a large number of locomotives with air brakes. Sixty thousand cars are to be fitted with the Westinghouse air brakes and the remaining 240,000 with air pipes and coupling within three years.

Experiments have recently been made with compressed air and compressed oxygen to purify the air in a long tunnel near Geneva, through which 200 trains pass every day. The compressed air is liberated from the cylinders on the engine. The pure air blew back the smoke and clarified the atmosphere. The oxygen was allowed to escape into the fires of the engines, causing complete combustion and preventing the formation of dangerous gases, as well as making the air more wholesome by the addition of the oxygen. The compressed air was adopted because a cheaper method. This experiment suggests the feasibility of similar methods in running tunnels and possibly in the shafts and level workings of the mines.

Propositions have been made to the State Board of Health to use liquid air for disposing of New York City's garbage. The process would be to freeze the waste into solid masses and then separate it into various commercial products. The chief advantage claimed for this process is that it is odorless.

Announcement is made of the organization of the New York Air Compressor Company under the laws of the State of New Jersey. The capital stock of the company is $100,000, and a complete foundry and machine shop plant has been purchased on the line of the New York & Greenwood Lake Railroad at Arlington, N. J. Contracts have already been let for a full modern equipment of tools.

It is intended to manufacture a complete line of air compressing machinery at the new plant.

The officers of the company are: J. W. Duntley, president; Alexander MacKay, vice-president; W. P. Pressinger, secretary and treasurer.

The director are: J. W. Duntley, Alexander MacKay, W. P. Pressinger, William B. Albright, W. O. Duntley, Thomas Aldcorn and Austin E. Pressinger .

The New York offices of the company are at 120 Liberty street.

"Don't Let's Vait," Says Sinkers.

When Sarsaparilla Reilly Tells Him There'll Be No Beer in 2000.

When Sarsaparilla Reilly entered the little restaurant the Sinker Man was polishing a tin pie plate.

"I see you're washin' dishes," remarked Reilly.

"Dem is not dishes," said Sinkers. "Dem's a pie plate."

"Well," replied Reilly, "afore long they won't be needed. Mind what I'm tellin' yer, Sinkers, the inventors are makin' such rapid strides wid streetless carriages that it won't be long afore we'll have electric mince pies for Christmas dinners."

"Did Edinson invention dot?" asked the Sinker Man.

"Invention what?"

"Electric pies."

"No," said Reilly, "but he will. He's now workin' on the model of a hot air bun, an' afore Christmas time you and me'll be atin' electric pie."

"How fast we are going," remarked Sinkers, looking into space. "My head is dizzy."

"Well," said Reilly, "it'll be much dizzier next month. On December thirty-wan we'll travel nineteen billion million miles a minute and jump from this century into th' year 2000 A. D."

"For what is A. D.?" asked Sinkers.

"That stands for Anty-Diluvian," replied Reilly.

"My, how old she is!" said the Sinker Man. "Is her teeth shust so good to eat 'lectric pie?"

"Who?"

"Aunty what-is-it for her name."

"She's not a lady," said Reilly. "Anty-Diluvian means the Johnstown flood. But cuttin' that out, Sinkers, when the year 2000 gets here we'll be livin' on hot air and electhricity. In th' mornin' instead of coffee ye'll call for a cup of nitrogen wid a spoonful av gasolene. For dinner ye'll have electric frankfurters wid steam heated sauerkraut. Then there'll be sunlight potatoes, incandescent onions, wireless tomatoses, fluoroscope sardines, kinetographic cauliflowers and tamed lighting pudding. In them days we'll telegraph our food to our stomachs an' digest it wid dynamite. Our vision will become so perfected that we'll be able to see clear through the side of a brick house. We'll be able to hear what the people of China are telling the people of Japan, and we'll flirt with the girls up in Mars."

"Vhat vould Lena say?" asked Sinkers.

"Sure yer wife wudn't know it," answered Reilly. "Whin you'd be flirting wid the girls, she'd be lallygagging wid the man in the moon."

"I'll kill him," exclaimed the Sinker Man.

"Who?" asked Reilly.

"Der man in der moon," said Sinkers. "Don't he know my vife is married?"

"Stop!" commanded Reilly. "You're a hundred years ahead of yourself. I'm talking av the year 2000. In them days the birds av the air will swim in the sea and th' fish av the sea 'll fly in the air."

"Von't dot be fine?" said Sinkers. "Den ve can go fish-shooting mit a bird gun und bird-fishing mit a fish hook; vhat?"

"Well," said Reilly, "we'll shoot fish from flying machines and fish for birds from submarine boats."

"Und vhat kind of beer vill ve drink?" asked Sinkers.

"There'll be no beer," answered Reilly "In them days ye'll have to drink nitrate of soda cocktails."

"Don't let us vait," said Sinkers.

So they went next door to Red Jerry's and ordered old fashioned soothing syrup for two.—*New York Sun.*

An apparatus by means of which a railway guard can shut and lock all the doors in a train, by moving a lever in his van, has recently been tried on a train on the Metropolitan District Railway. This invention, which, we understand, has been at work successfully in Australia, and is known as the Fraser railway door controller, is actuated by compressed air, which can be supplied to cylinders fixed under the carriages. By a combination of pistons, rods, levers, and springs the doors can be made to shut, and this can all be done by the guard from his van, without his touching a single door. The action is said to be so gentle that, even if people's fingers get in the doors, these are only prevented from closing, and no injury results to the fingers. The apparatus, it is said, can be worked either by means of the air in the air-brake pipes, or by means of a separate air pump, or with modifications in connection with the vacuum brake.

PATENTS GRANTED OCT., 1899.

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632,529. PNEUMATIC INSOLE. Anton Korwan, New York, N. Y. Filed January 3, 1899. Serial No. 700,892. (No model.)

An insole, consisting of a lower layer, an air-tight cushion located upon and extending transversely of and entirely across the same at its narrow portion below the hollow of the foot, and an upper layer upon said lower layer and cushion, said layers being disconnected from each other for a short distance each side of said cushion, so as to form air-passages between the layers at each side of the cushion, substantially as set forth.

634,042. PNEUMATIC CARPET-RENOVATOR. John S. Thurman, St. Louis, Mo.

A combination, with a suitable casing, of a blast-nozzle carried thereby, which discharges through the bottom of said casing, said casing being provided with suitable transversely-disposed walls forming a conducting-passage for the dust-laden air, and a chamber in which said dust-laden air is discharged, and a removable section secured in the upper end of said casing, which removable section consists of transversely-arranged walls forming a tortuous passage which connects with the dust-collecting chamber, said transversely-disposed walls of the casing, and removable section forming pockets at the bends of the tortuous passage for the collection of dust and dirt; substantially as described.

634,348. AIR-FEEDING APPARATUS FOR BOILER-FURNACES. James Howden, Glasgow, Scotland.

Apparatus for supplying and heating air for water-tube steam-boiler furnaces, comprising in combination means for forcing or drawing air through the apparatus and furnace-casings in which the air is heated, fire-gas tubes in the said casing, air-distributing boxes at the front and back ends and sides of the furnace, inclosed spaces to convey the air from the casing to the distributing-boxes and valves for controlling and regulating the distribution substantially as set forth.

634,389. DIRECT-ACTING AIR-COMPRESSING ENGINE. Peter Brotherhood, London, England.

A direct-acting air-compressing engine comprising a double-acting steam-cylinder having its piston connected to the piston of an air-compressing cylinder in line with the steam-cylinder, and two other air-compressing cylinders having their pistons connected to the same crank with the other and the air-cylinders being provided on their outer ends with apertures furnished with suitable suction and discharge valves, substantially as described.

The combination with a shaft, and a plurality of radially-arranged air-compressing cylinders having their pistons connected with the shaft, of a double-acting steam-cylinder having its piston rigidly connected by a piston-rod with the piston of one of said air-compressing cylinders, substantially as described.

634,723. AIR-BRAKE. Chauncey N. Dutton, New York, N. Y. Filed October 23, 1897.

634,788. AIR GOODS. Albert A. Young, Wakefield, Mass. Filed April 10, 1899. Serial No. 712,378. (No model.)

In combination the sack-walls, A, B, having the perforations, *t*; the buttons, *f*, having openings, *v*, and a curved face engaging the outer faces of said walls respectively; a flexible cord having its ends respectively secured in said openings and passing through said perforations; and the caps, *d*, covering said buttons and vulcanized to said walls, all being arranged to operate as specified.

635,419. AIR-COMPRESSING APPARATUS. Stephen Broichgans, Milwaukee, Wis. Filed Oct. 10, 1898.

An air-compressing mechanism comprising a closed tank provided with a liquid-inlet, an air-conduit open to the tank above the liquid-level therein, but provided with an air-inlet outside of said tank governed by a check-valve, a central chamber rising from the tank-bottom but provided with perforations at its lower end, another air-conduit having open-end union with the otherwise closed top of the chamber and provided outside the aforesaid tank with an air-inlet governed by a check-valve, an open-bottom weighted jacket surrounding said chamber, a cylinder having valve-controlled inlet and outlet for a fluid under pressure, a piston in the cylinder, a rod connecting the jacket and piston, a reciprocative holder in communication with the air-conduits and a distributer-pipe, and a valve-shifting mechanism operative in conjunction with the piston-rod and said holder.

635,434. TERMINAL FOR PNEUMATIC-DESPATCH-TUBE SYSTEMS. Edmond A. Fordyce, Chicago, Ill. Filed Aug. 3, 1899.

A discharge-terminal for pneumatic-despatch-tube systems, comprising a receiving tube-section at the end of and communicating with a main or branch line of the system, two transversely-sliding gates in said tube-section adapted to receive a carrier between them, the first of said gates being normally open and the second closed, and a single motor connected to both of said gates and actuating them successively, whereby, on the arrival of a carrier to be discharged, the first gate is first closed in the rear of the carrier and then the second gate is opened to permit the carrier's discharge.

635,478. HYDRAULIC AIR-PUMP. George J. Habermann, Cleveland, Ohio. Filed June 10, 1898. Serial No. 683,139.

The valve K constructed to slide in its seat and to control both the inlet and the outlet passages to the piston-chamber, a lever J pivoted between its ends and mechanically connected with said value at its upper end, a weighted swinging arm G pivoted on the same centre as the said lever J and having a pair of fingers at its bottom and sides with their lower extermities in position to strike said lever below its pivot-point and thus reverse valve K, and hydraulic-actuated means to tilt the arm G comprising float C, lever D connected therewith and projections on said lever to strike opposite sides of said arm, in combination with the pump-casing N and a combined piston L and valve M in said casing controlling the entrance and discharge of the water to and from the chamber B, substantially as described.

635,516. AIR-COMPRESSOR. John P. Simmons, San Francisco, Cal., assignor to Squire V. Mooney, same place.

A compressor comprising a cylinder having suitable outlets a cage-piston therein provided with a valve-controlled port in each end thereof communicating with the interior of the cylinder on opposite sides, and an annular recess or pocket exterior to and separate from said port, in which the stem of the valve is guided.

635,517. AIR-COMPRESSOR. John P. Simmons, San Francisco, Cal., assignor to Squire V. Mooney, same place. Filed Feb. 22, 1898.

In a compressor a power-cylinder and a piston therein, a compressor-cylinder and a piston therein, a crank-shaft and a bell-crank connecting-rod connecting the

power-piston crank and compressor-piston by its attachment to the bell-crank.

In a compressor a power-cylinder and a piston therein, a compressor-cylinder and a piston therein said cylinders being arranged with respect to each other, in the same vertical plane but their centres in different horizontal planes and a bell-crank connecting-rod connecting the power-piston and crank, and connecting the compressor-piston by its attachment to the bell-crank.

635,661. AIR-VALVE. William J. Cole, Evansville, Ind. Filed June 15, 1898.

A valve for pneumatic tires, with a casing and valve-seat piece in combination with a combined metal and rubber conical valve as aforesaid, a valve-stem extending through the longitudinal passage in said valve-seat piece and receiving on its externally-threaded end a grooved set-nut, adapted to force and hold the valve against the valve-seat.

635,674. PORTABLE AIR-PUMP. Albert B. Diss, New York, N. Y. Filed July 19, 1898. Serial No. 686,351. (No model.)

A cylinder, piston-rod, double-acting piston and inlet air-valves, a coupler or bend connected with one head and forming an air-passage, a valve-case connected with the cylinder near the other end thereof, and a connecting-tube, there being a lateral branch to the valve-case for the air exit and a flat chamber therein, and a valve in the chamber formed of a strip of leather or similar material and smaller than the chamber, there being lips at the end of the branch for retaining the valve in position, substantially as set forth.

635,095. AUTOMATIC AIR-BRAKE. William H. Clarke, New York, N. Y.

636,013. AIR-COMPRESSOR. George W. Tolle, St. Louis, Mo.

An air-compressing apparatus comprising an air-pump, a receiver, two intermediate communicating cylinders, pipe connections between the cylinders and air-pump, valves controlling the communication between said pipe connections and the cylinders, valve-actuating disks for said valves, a valve-reversing disk, slotted links connecting said valve-reversing disk to said valve-actuating disks, a plunger for each cylinder, link or lever connections between the plungers and valve-reversing disk, a piston for each cylinder, a suitable inlet and check valves for the several pipes, an air-cylinder or dash-pot, and a link connection between the piston of the dash-pot and valve-reversing disk, the parts operating as and for the purpose set forth.

636,090. AIR-HEATER. Edwin R. Waterman and Robert R. Morison, San Francisco, Cal.; said Waterman assignor to Percy S. Regnart, same place.

An air-heater comprising the combination of an outer casing having a removable handle portion fitted to its rear end, an air-conducting pipe interior to the casing, a heater surrounding the pipe, a nozzle inserted in place through the rear end of the casing and having an enlarged base-flange to seat against the interior of the front end of the casing, and a connection through which air is delivered through the heating-pipe.

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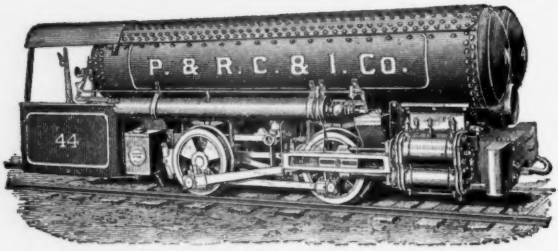

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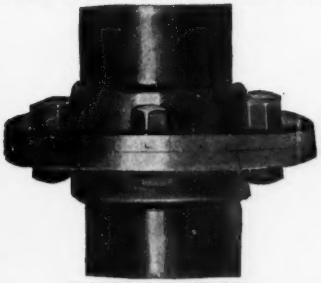

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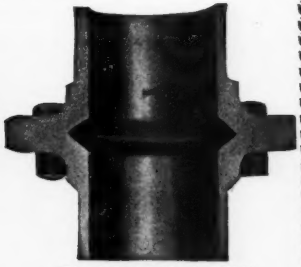

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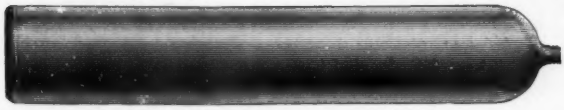

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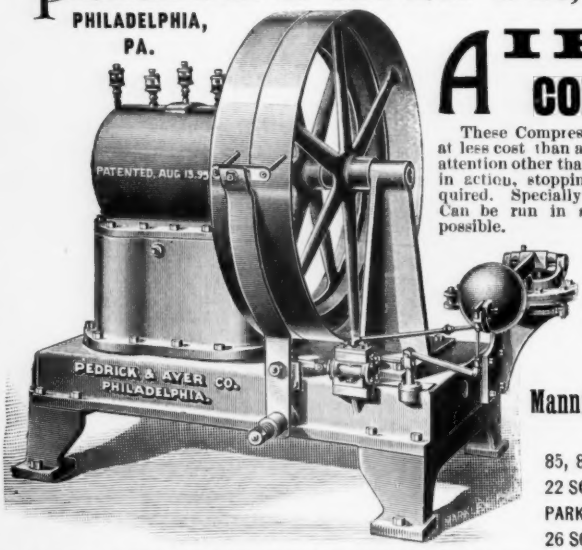

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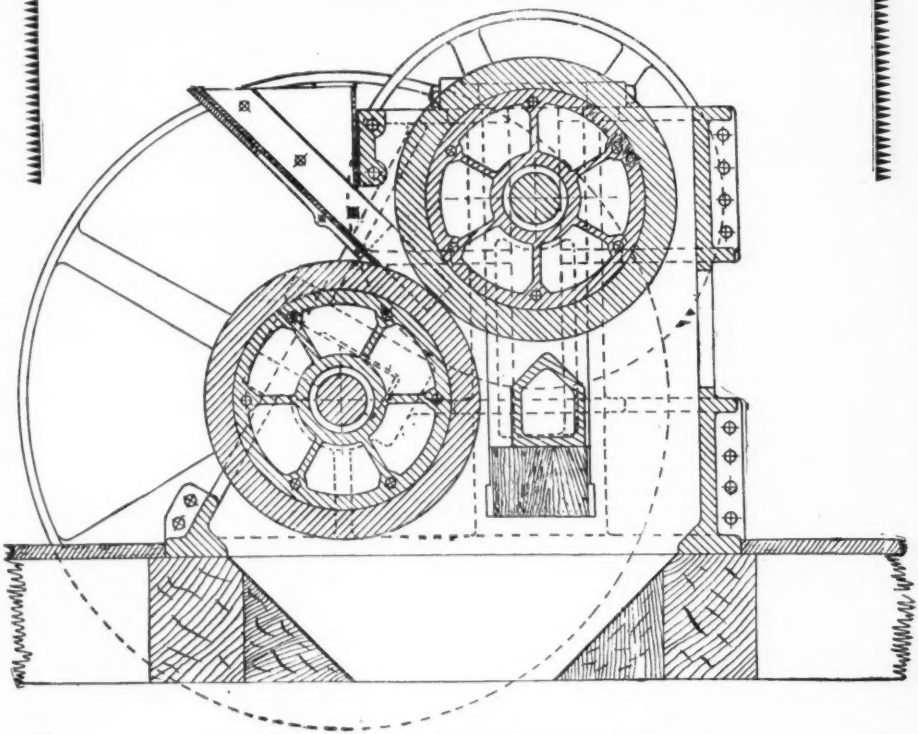

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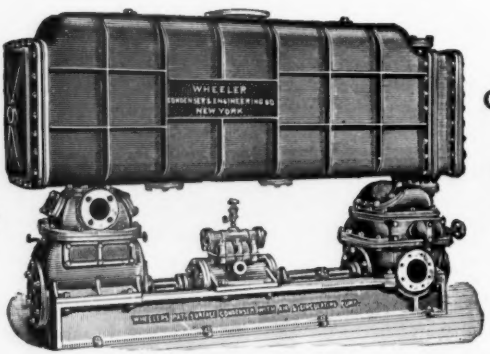

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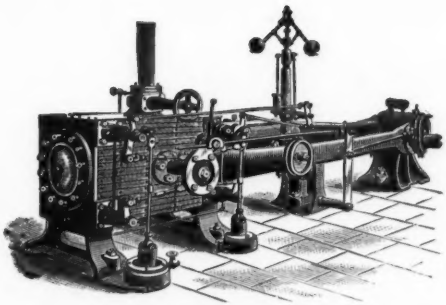

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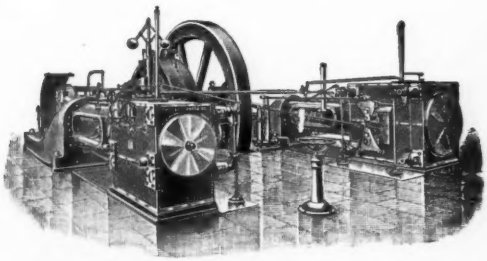

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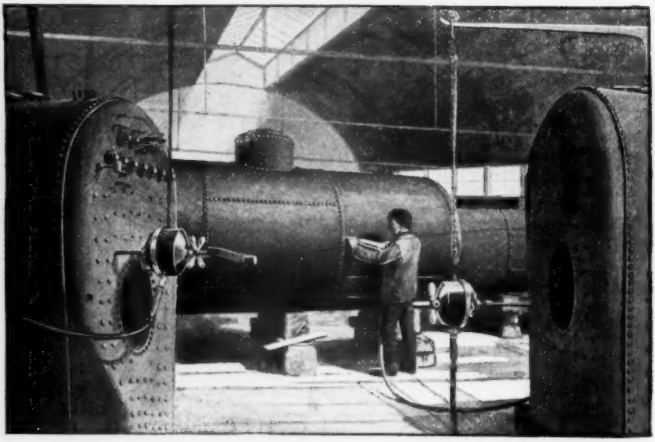

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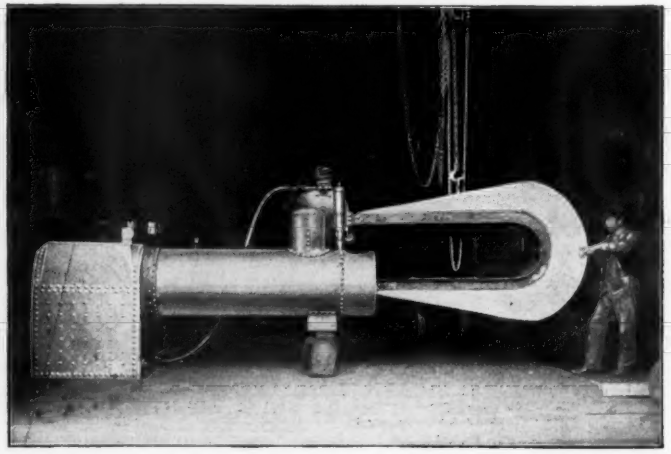

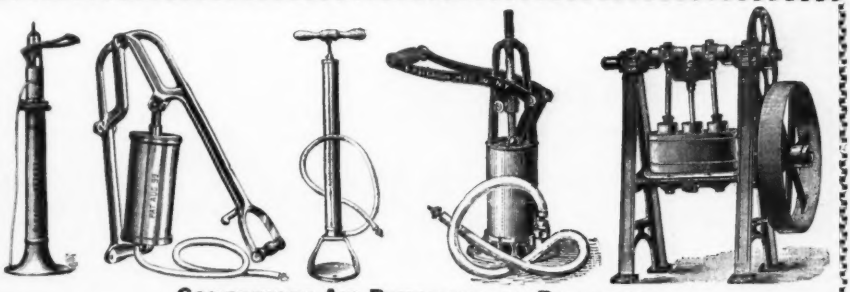

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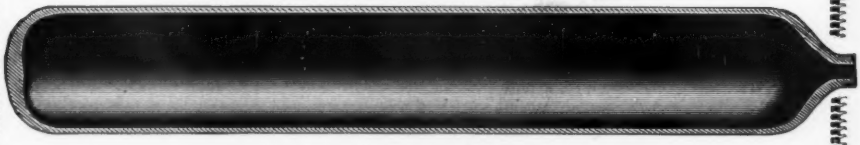

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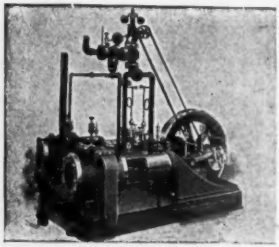

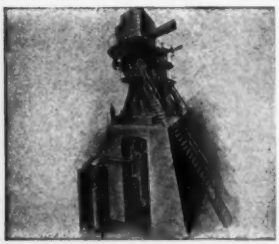

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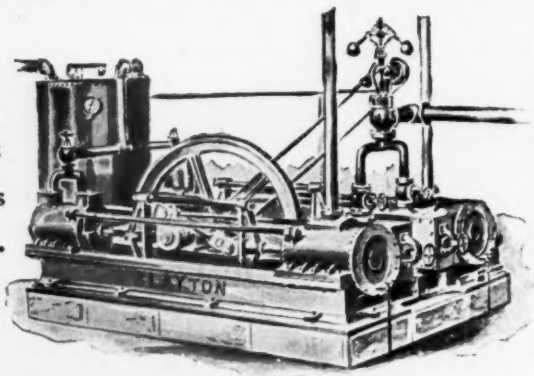

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